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Abstract

Background: This study assessed characteristics of head, face, and neck injury among US military casualties from the stability and support phase of Operation Iraqi Freedom.

Methods: A retrospective analysis of trauma registry data was performed. Data were collected from the US Navy and Marine Corps Combat Trauma Registry for the time period of 1 March to 30 September 2004.

Results: Four hundred and forty-five casualties with head, face, or neck injury were identified for analysis. Of these, 140 (31%) sustained multiple wounds to the head, face, and neck; 177 (40%) had head wounds; 336 (76%) had facial wounds; and 84 (19%) had neck wounds. Head, face, and neck wounds accounted for 61% of the total 1,666 injuries incurred. Improvised explosive devices were the most frequent cause of injury among battle casualties, whereas motor vehicle crashes were the most common cause of injury among nonbattle casualties. The overall mean abbreviated injury severity scores for head, face, and neck injuries were 2.1, 1.1, and 1.2, respectively.

Conclusions: Although the majority of casualties incurred wounds to the face, head and neck injuries were generally more severe, especially among those who died of wounds. The high frequency of facial wounding suggests, however, that the face may be more vulnerable during armed conflict than the head or neck.

Key Words: combat, casualty, head injury, Operation Iraqi Freedom

Introduction

Traumatic injuries to the head, face, and neck have been a major contributor to the mortality and morbidity of US armed forces injured during hostile action.¹⁻⁷ Although the head, face, and neck comprise only 12% of the total body surface area exposed during combat,¹ these body areas sustained proportionately more injuries and proportionately more injuries leading to death during the major conflicts of the 20th century. During World War II, the Korean War, and Vietnam War, head, face, and neck wounds accounted for more than 40% of deaths (more than any other body region) among US armed forces.²⁻⁴ The mean relative incidence of head, face, and neck injury was approximately 16% based on a meta-analysis of major armed conflicts from 1914 to 1986.⁸ This pattern remains evident in current warfare. During the major combat phase of Operation Iraqi Freedom (OIF-I), US Navy and Marine Corps forces wounded in action sustained approximately 19% of all wounds to the head, face, or neck.⁹

Despite the prevalence of head, face, and neck injuries during war, few studies have addressed the severity and types of these injuries. An analysis of wounds to the head, face, and neck would facilitate the determination of resource needs of future operations as well as potential improvements to modern individual body armor with respect to the head, face, and neck. The present study provides such an assessment of head, face, and neck injuries sustained by US military forces during the stability and support phase of Operation Iraqi Freedom (OIF-II) from March to September 2004.

This paper also identifies the primary causes of battle and nonbattle injury to the head, face, and neck during OIF-II. Research on previous conflicts^{6,10} has found that most injuries sustained during hostile action are due to small arms and explosive munitions. During OIF-I, explosive munitions such as rocket-propelled grenades accounted for the majority of head, face,

and neck wounds sustained in action.⁹ Conversely, researchers^{2,10} reported motor vehicle crashes and falls as the primary causes of nonbattle injuries during armed conflict. This study will examine whether the same causes of injury were observed in OIF-II.

Methods

Data were obtained from the US Navy and Marine Corps Combat Trauma Registry (Navy–Marine Corps CTR) in a retrospective review of head, face, and neck injuries incurred during the time period from 1 March to 30 September 2004 of OIF-II. The Navy–Marine Corps CTR is a data warehouse maintained by the Naval Health Research Center (NHRC), San Diego, CA, to collect and store personal health information on US service members who receive initial care for battle or nonbattle injuries at Navy–Marine Corps military medical treatment facilities (MTFs). Examples of Navy–Marine Corps MTFs include battalion aids stations (ie, Level I), which provide initial resuscitative intervention; and Shock Trauma Platoons, Forward Resuscitative Surgical Systems, and Surgical Companies, which provide advanced resuscitative intervention and damage control surgical procedures (ie, Level II). Information regarding patient demographics, incident details, injuries, treatment, and outcomes is collected by the patient's medical provider(s) in the form of a clinical record. Clinical records are then sent to NHRC for data management and analysis. The Navy–Marine Corps CTR clinical research personnel compile the medical records of each patient and evaluate the severity of these patients' injuries.

In the present study, the clinicians identified patients with head, face, and neck injury for analysis. Head injuries included trauma to the skull and brain; facial injuries included trauma to the facial bones, eyes, ears, nose, and mouth; and neck injuries included trauma to cervical area and cervical spine.

Descriptive measures included casualty types, causes of injury, injuries, and injury severity scores. Casualties were divided into two main categories: battle injury, defined as those who suffered an injury to the head, face, or neck as a direct result of hostile action; and nonbattle injury, defined as those who sustained an injury to the head, face, or neck that was not due to hostile action. Battle injury casualties were further defined as died of wounds (ie, those who died from wounds received in action following treatment at an MTF); or wounded in action (ie, those who survived wounds sustained in action). Wounded in action and nonbattle injury casualties were analyzed as a function of their disposition: returned to duty from a Level I or Level II MTF; or medically evacuated to a Level III MTF (ie, Combat Support Hospital) or higher level of care. Each of the above-mentioned categories were mutually exclusive.

Injury severity was assessed with the Abbreviated Injury Scale (AIS) 2005¹² and the Injury Severity Score (ISS).¹³ The AIS provided anatomically specific severity scores for each injury (ie, head, face, or neck injury), whereas the ISS was used to assess the overall injury severity of each patient, which included injuries from all anatomical locations. Analyses were also performed for protective equipment worn at the time of injury, disposition, anatomical location of injury, *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM)¹⁴ codes, and the Glasgow Coma Scale (GCS).

Differences in AIS, ISS, and GCS scores were compared between medically evacuated and returned to duty populations among battle and nonbattle injury casualties. The 2 sample *t* test for independent samples and Mann-Whitney *U* test were used, as appropriate. All statistical analyses were performed using SPSS software version 12.0.2 (SPSS Inc., Chicago, IL); all tests were 2-tailed and $P \leq .05$ was used to determine statistical significance. Mean values are presented as means \pm SD unless otherwise indicated.

Results

Four hundred and forty-five US military casualties with head, face, or neck injuries were identified for analysis, which accounted for 39% of all injury casualties in the Navy-Marine Corps CTR from 1 March to 30 September 2004. Of the 445 casualties, four Marine Corps incurred two separate injury events during the study period; each injury event was counted as 1 casualty. Average age (with 69 unknown) was 24 ± 5.9 years, with a range of 18 to 48 years. All but 6 casualties were male. Of the 445 casualties, 381 were Marine Corps, 45 were Army, 14 were Navy, and 1 was Air Force. Military service category was unknown for 4 casualties.

Among the 445 head, face, and neck injury casualties, 19 (4%) were classified as died of wounds, 315 (71%) were wounded in action, and 111 (25%) sustained nonbattle injuries. Of the wounded in action, 144 (46%) were medically evacuated to a Level III MTF or higher level of care, and 171 (54%) of the casualties were returned to duty from a Level I or Level II MTF. Of the nonbattle injury casualties, 26 (23%) were medically evacuated and 85 (77%) were returned to duty.

As shown in Table 1, the most common causes of head, face, and neck injury among battle casualties were improvised explosive devices (64%), mortars (11%), gunshot wounds or bullets (7%), and other explosives (6%).

Table 1. Causes of Battle Injury ($n = 334$)

Cause of Injury	Casualties No. (%)
Improvised explosive device	214 (64)
Mortar	36 (11)
Gunshot wound/bullet	22 (7)
Explosive (NOS)	21 (6)
Rocket-propelled grenade	14 (4)
Fragmentation (NOS)	13 (4)
Landmine	8 (2)
Aircraft crash	4 (1)
Grenade	1 (<1)
Unknown	1 (<1)

NOS, not otherwise specified.

As shown in Table 2, nonbattle injury casualties sustained head, face, and neck injury from primarily vehicle accidents (31%), unspecified blunt trauma (19%), sports recreation and training (14%), flying debris (11%), and falls (10%).

Table 2. Causes of Nonbattle Injury ($n = 111$)

Cause of Injury	Casualties
	No. (%)
Motor vehicle crash	34 (31)
Blunt trauma (NOS)	21 (19)
Sports recreation/training	15 (14)
Flying debris	12 (11)
Fall	11 (10)
Assault/altercation	8 (7)
Crush	3 (3)
Explosive (NOS)	3 (3)
Hot object/liquid	3 (3)
Knife/edge	1 (1)

NOS, not otherwise specified.

More than 80% of battle casualties (279/334; with 21 unknown) were reported wearing helmets at the point of injury. Only 68% (228/334; with 52 unknown), however, were reported wearing protective eyewear at the point of injury. As shown in Table 3, casualties reported not wearing helmets were injured primarily by mortars (indirect fire), whereas casualties reported not wearing eyewear were injured primarily by improvised explosive devices (direct fire).

Table 3. Protective Equipment Reported as Not Worn, by Cause of Injury*

Cause of Injury	Equipment Not Worn	
	Helmet ($n = 21$)	Eyewear ($n = 52$)
Mortar	13 (62)	16 (31)
Improvised explosive device	4 (19)	22 (42)
Explosive (NOS)	2 (10)	4 (8)
Fragmentation (NOS)	1 (5)	4 (8)
Rocket-propelled grenade	1 (5)	2 (4)
Gunshot wound/bullet	0	2 (4)
Landmine	0	2 (4)

NOS, not otherwise specified.

*Values are number (percentage). Because of rounding, percentages may not total 100.

Overall, casualties incurred a total of 1666 injuries. Of these, 61% (1011) were injuries to the head, face, or neck. Of the 445 casualties, 140 (31%) sustained multiple wounds to the head, face, and neck; 177 casualties (40%) had head wounds; 336 (76%) casualties had facial wounds; and 84 (19%) had neck wounds. As shown in Table 4, the most frequent location of injury among those who died of wounds was the head. Among the wounded in action and nonbattle injury casualties, the most frequent location of injury was the face.

Table 4. Distribution of Anatomical Location of Injuries by Disposition

Injury Location	No. (%) of Injuries*					
	All (N = 1011)	Died of Wounds (n = 60)	Wounded in Action		Nonbattle	
			MEDEVAC (n = 478)	RTD (n = 296)	MEDEVAC (n = 47)	RTD (n = 128)
Head	259 (26)	29 (48)	115 (24)	68 (23)	13 (28)	34 (26)
Face	653 (65)	20 (33)	319 (67)	201 (68)	32 (68)	81 (63)
Neck	99 (10)	11 (18)	44 (9)	27 (9)	2 (4)	15 (12)

MEDEVAC, medically evacuated; RTD, returned to duty.

*Because of rounding, percentages may not all total 100.

The distribution of specific injury descriptions and injury codes, as provided by ICD-9-CM, are presented in Table 5. Approximately 45% (450/1011) of all head, face, and neck injuries were coded as open wounds (ICD-9-CM codes 870 to 897). “Intracranial injury” was the most common diagnosis among injuries specific to the head. The most common facial injury diagnosis was “other open wounds of the head,” which included only those ICD-9-CM codes anatomically specific to the face (873 to 873.9). Notably, there were 156 injuries of the eye and ocular adnexa. “Open wound of the neck” was the most common neck injury.

Table 5. Distribution of Injuries and ICD-9-CM Codes by Anatomical Region by Disposition

Injury Description	ICD-9-CM Code(s)	No. (%) of Injuries*					
		All (N = 1011)	Died of Wounds (n = 60)	Wounded in Action		Nonbattle	
				MEDEVAC (n = 478)	RTD (n = 296)	MEDEVAC (n = 47)	RTD (n = 128)
Head							
Intracranial injury, excluding skull fracture	850-854	128 (13)	18 (30)	56 (12)	32 (11)	7 (15)	15 (12)
Other open wound of head	873	52 (5)	4	21	14	1	12
Fracture of base and vault of skull	800,801	33 (3)	6 (10)	24 (5)	2 (<1)	1 (2)	0
Injury to other cranial nerve(s)	951	26 (3)	1 (2)	7 (2)	18 (6)	0	0
Other conditions of the brain	348	1 (<1)	1 (2)	0	0	0	0
Face							
Other open wound of head	873	184 (18)	7 (12)	90 (19)	60 (20)	6 (13)	21 (16)
Open wound of ear	872	94 (9)	2 (3)	40 (8)	49 (17)	1 (2)	2 (2)
Fracture of face bones	802	65 (6)	1 (2)	57 (12)	0	5 (11)	0
Open wound of ocular adnexa and eyeball	870,871	64 (6)	4 (7)	47 (10)	3 (1)	6 (13)	4 (3)
Superficial injury of the eye and adnexa	918	39 (4)	0	24 (5)	5 (2)	3 (6)	7 (6)
Contusion of eye and adnexa	921	36 (4)	3 (5)	22 (5)	2 (1)	6 (13)	3 (2)
Foreign body on external eye	930	5 (<1)	0	0	0	0	5 (4)
Burn confined to eye and adnexa	940	5 (<1)	1 (2)	1 (<1)	0	0	3 (2)
Injury to optic nerve and pathways	950	3 (<1)	0	2 (<1)	1 (<1)	0	0
Other disorders of the eye	379	3 (<1)	0	3 (1)	0	0	0
Neck							
Open wound of neck	874	56 (6)	7 (12)	30 (6)	19 (6)	0	0
Sprains and strains of neck	847.0	22 (2)	0	2 (<1)	5 (2)	1 (2)	14 (11)
Fracture of vertebral column	805,806	6 (1)	0	6 (1)	0	0	0
Other, multiple, and ill-defined dislocations	839.0	1 (<1)	0	1 (<1)	0	0	0
Other, multiple, and ill-defined							
Superficial injury of face, neck, and scalp	910	61 (6)	0	12 (3)	26 (9)	4 (9)	19 (15)
Injury, other and unspecified	959.0	54 (5)	0	3 (1)	48 (16)	1 (2)	2 (2)
Burn of face, head, and neck	941	35 (3)	2 (3)	16 (3)	5 (2)	2 (4)	10 (8)
Contusion of face, scalp, and neck	920	27 (3)	0	9 (2)	6 (2)	3 (6)	9 (7)
Injury to blood vessels of head and neck	900	7 (1)	3 (5)	4 (1)	0	0	0
Burns according to extent of body surface	948	4 (<1)	0	1 (<1)	1	0	2 (2)

ICD-9-CM, *International Classification of Diseases, 9th Revision, Clinical Modification*¹⁴; MEDEVAC, medically evacuated; RTD, returned to duty.

*Because of rounding, percentages may not all total 100.

A higher AIS score, on a scale of 1 to 6, indicates more severe injury. The overall mean AIS scores (with 13 unknown) were 2.1 ± 1.3 for the head, 1.1 ± 0.3 for the face, and 1.2 ± 0.7 for the neck. Comparisons of injury severity by AIS body systems across dispositions are shown in Table 6. Among casualties wounded in action, the mean AIS scores for head, face, and neck body systems were significantly higher among medically evacuated patients than for those who were returned to duty. There were no statistical differences for mean AIS scores between medically evacuated and returned to duty nonbattle injuries.

Table 6. Comparison of Abbreviated Injury Scale (AIS) 2005¹² for Injuries by Body System Across Dispositions*

AIS Body System	Died of Wounds	Wounded in Action			Nonbattle		
		MEDEVAC	RTD	<i>P</i>	MEDEVAC	RTD	<i>P</i> †
Head	4.1 (1.7)	2.6 (1.3)	1.4 (0.6)	<.001	1.3 (0.7)	1.3 (0.4)	.72
Face	1.1 (0.2)	1.2 (0.4)	1.0 (0.1)	<.001	1.1 (0.3)	1.0 (0.2)	.19
Neck‡	2.0 (1.3)	1.3 (0.8)	1.0 (0.0)	.02	1.0 (NA)	1.0 (0.0)	...

MEDEVAC, medically evacuated; RTD, returned to duty.

*Values are mean (SD) unless otherwise indicated. A score of 1 is considered minor injury; the maximum score is 5 (critical injury).

†Ellipses indicate *P* value not computed.

‡Includes spine (cervical) AIS.

The ISS takes values from 1 to 75. A higher ISS score indicates more severe injuries. Of the 445 casualties, 373 (84%) had an ISS of 0 to 8; 30 (7%) had an ISS of 9 to 15; 14 (3%) had an ISS of 16 to 24; 24 (5%) had an ISS of 25 or greater; and 4 (1%) were unable to be coded. The median ISS for casualties who died of wounds was 25 (range, 1–57). Among wounded in action, the median ISS was higher for the medically evacuated compared with the returned to duty casualties (5 vs. 2, $P < .001$). Similarly, for nonbattle injury casualties, the median ISS was higher among the medically evacuated than the returned to duty (2 vs. 1, $P = .01$).

Of the 409 casualties who had a documented GCS score on admission to a Navy–Marine Corps MTF, the majority (91%) had minor or no evidence of head injury (GCS 13 to 15). The mean GCS score on admission among those who later died of wounds was 5.2 ± 3.6 , indicating

severe head injury. Among the wounded in action, the mean GCS score was lower for medically evacuated than returned to duty casualties (14.2 ± 2.3 vs. 15.0 ± 0.2 ; $P < .001$). Among nonbattle injury casualties, the mean GCS score was also lower for medically evacuated than returned to duty, but not statistically different (14.2 ± 2.0 vs. 15.0 ± 0.4 , $P = .11$). The effect size for the combination of these groups, however, was small ($h^2 = .00$, $P = .80$, 95% confidence interval = $-0.89, 0.69$). Thus, there is no evidence that the effect of disposition (ie, medically evacuated or returned to duty) on GCS score differs between wounded in action and nonbattle injury casualties.

Discussion

Consistent with research on OIF-I,⁹ the primary causes of head, face, and neck battle injuries in the present study were explosive munitions such as improvised explosive devices and mortars. Although more than 80% of battle casualties wore helmets, only 68% were reported wearing protective eyewear at the point of injury. Mortars were the primary cause of injury among those not wearing helmets and improvised explosive devices were the primary cause of injury among those not wearing protective eyewear. Speculatively, casualties who were not wearing their helmets at the point of injury may have been injured more frequently by indirect fire, such as mortars, rather than direct fire because they perceived themselves to be in an environment safe from hostile action.

Motor vehicle crashes were the most common cause of injury among nonbattle casualties. These findings are consistent with previous research from OIF-I indicating that motor vehicle crashes cause the majority of nonbattle injuries during hostile action,¹¹ and result in the highest number of nonbattle injury admissions.⁷ These prior assessments also indicate that falls have been a notable cause of nonbattle injuries and nonbattle injury admissions, which included

injuries from all anatomical locations. In our analysis falls were not a major contributor to nonbattle head, face, and neck injury suggesting that these regions may have been less susceptible to injury from a fall than other anatomical locations during OIF-II.

Wounding patterns among battle injury deaths are known to differ from that of battle injury survivors.¹⁵ In the present study, the face was the predominant site of injury among the wounded survivors. The head, however, was the predominant site of injury among casualties who died of wounds. More than one third of all casualties presented with multiple injuries to the head, face, or neck. Consistent with research based on prior conflicts,^{2,3,9,11} open (or penetrating) wounds were altogether the most common injury diagnosis.

The severity of specific injuries (ie, AIS) and overall severity scores (ie, ISS) were expectedly higher for battle casualties who were medically evacuated compared with those returned to duty given that medical evacuation is protocol for the more severely injured patients. Similarly, among nonbattle injury casualties, ISS was higher for medically evacuated than returned to duty. Although the AIS scores were generally higher among the medically evacuated than returned to duty nonbattle casualties, they were not statistically different.

There have been relatively few descriptions of head, face, and neck injuries incurred during hostile action. The present results extend the existing literature in several ways. This study assessed the types of head, face, and neck injuries as well as the corresponding severity levels of each injury. The Navy–Marine Corps CTR is the only current US trauma registry to comprehensively collect injury-related personal health information at Level I and Level II MTFs. Furthermore, this sample from the CTR allowed us to analyze injuries among casualties who were returned to duty from the Level I and Level II MTFs as well as describe the frequency of protective equipment worn at the time of injury.

While this broad-based analysis provides important information in the assessment of the types of injuries and may aid in future military medical planning, it also presents a few limitations including the retrospective nature of the data, missing data, and the lack of denominator data, which precludes risk assessments. Although each of the US Armed Forces was represented in this examination, the large majority of casualties were Marines. Due to inherent differences in force operations and body armor, these data may not generalize to other military forces.

Despite these limitations, our results do indicate that casualty medical care resource allocation and planning should take into consideration the impact of facial injuries, especially with regard to improvements to modern individual body armor. Further research is required to identify the risks associated with head, face, and neck injury during hostile action. Outcome assessments are also needed in order to define the implications of survived head, face, and neck injury.

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14. ABSTRACT (maximum 200 words)

A retrospective analysis was performed to assess characteristics of head, face, and neck injury among US military casualties from Operation Iraqi Freedom Phase Two. Data were collected from the US Navy and Marine Corps Combat Trauma Registry for the time period of 1 March to 30 September 2004. Four hundred and forty-five casualties with head, face, or neck injury were identified for analysis. Of these, 140 (31%) sustained multiple wounds to the head, face, and neck; 177 (40%) had head wounds; 336 (76%) had facial wounds; and 84 (19%) had neck wounds. Head, face, and neck wounds accounted for 61% of the total 1,666 injuries incurred. Improvised explosive devices were the most frequent cause of injury among battle casualties, whereas motor vehicle accidents were the most common cause of injury among nonbattle casualties. The overall mean abbreviated injury severity scores for head, face, and neck injuries were 2.1, 1.1, and 1.2, respectively. Although the majority of casualties incurred wounds to the face, head and neck injuries were generally more severe, especially among those who died of wounds. The high frequency of facial wounding suggests, however, that the face may be more vulnerable during armed conflict than the head or neck.

15. SUBJECT TERMS

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